Indian J. Phys. **70A** (1), 173–177 (1996)

IJP A
— an international journal

Structure of collective bands in $^{76,78,80,82}Sr$

K C Tripathy
Physics Department, Khallikote College, Berhampur-760 001, India
and
R Sahu
Physics Department, Berhampur University, Berhampur-760 007, India

Abstract : The structure of collective bands in $^{76-82}Sr$ is investigated within the frame work of the deformed configuration mixing shell model based on HF states The single particle orbits $1p_{3/2}$, $0f_{5/2}$, $1p_{1/2}$ and $0g_{9/2}$ are taken as the active configuration space with ^{56}Ni as the inert core A modified Kuo interaction for this basis space is used We find ^{76}Sr to have the largest deformation in this mass region. The levels obtained on angular momentum projection from different intrinsic states are classified into different bands on the basis of the $B(E2)$ values among them The agreement with experiment is quite satisfactory

Keywords : Structure of collective bands, $^{76-82}Sr$, deformed configuration mixing shell model

PACS Nos. 21 10 Re, 21 60 Cs

1. Introduction

The nuclei in the mass region $A = 80$ show interesting patterns of deformation and complex band structures. In particular the neutron deficient strontium isotopes have been observed to have extreme prolate deformation with $\beta \simeq 0.4$ [1]. It would be quite interesting to study these nuclei within our deformed configuration mixing shell model based on Hartree-Fock states [2]. We are particularly interested to study the changes in nuclear structure and deformation as neutrons are added to the $N = Z$ nucleus ^{76}Sr.

2. Deformed shell model calculation

In our calculation, we take ^{56}Ni as the inert core with $1p_{3/2}$, $0f_{5/2}$, $1p_{1/2}$ and $0g_{9/2}$ as the single particle orbits. The single particle energies of these orbits are taken as 0.0, 0.78, 1.08 and 3.5 MeV, respectively. We have used a modified Kuo interaction. Our calculation proceeds in the following steps : For each nucleus, we obtain the lowest and lowlying HF states by solving the deformed axially symmetric HF single particle equation. Good angular

Figure 1. HF single particle spectrum for ^{76,78,80,82}Sr

momentum states are projected from each of these intrinsic states and then a band mixing calculation is performed [3].

The prolate HF single particle spectra for the four nuclei are given in Figure 1. An analysis of the HF single particle spectrum of the $N = Z$ nucleus ^{76}Sr shows that the last two pairs of protons (or neutrons) occupy $k = 1/2^+$ and $k = 3/2^+$ orbitals, both of which have large positive quadrupole moment. There is a gap of about 2 MeV above the fermi level. The next higher orbitals are $k = 3/2^-$ and $k = 5/2^-$, both of which have negative quadrupole moment. If the neutron and (or) proton number is increased beyond $N = Z = 38$, then the additional nucleons will occupy $k = 3/2^-$ and $k = 5/2^-$ orbitals and hence the quadrupole moment will decrease resulting in lower deformation. If the proton and (or) neutron no. is decreased, then $k = 3/2^+$ and $k = 1/2^+$ orbitals will be progressively unoccupied resulting in lower quadrupole moment. Actual calculation also shows that ^{78,80,82}Sr have lower quadrupole moment. Thus our calculation shows that ^{76}Sr has the largest deformation in this region. Such a conclusion is also borne out in the experimental measurements of Lister *et al* [1].

For describing the positive parity bands of these nuclei, we have considered 5, 10, 9 and 8 intrinsic states for ^{76,78,80,82}Sr, respectively. As discussed above, good angular momentum states are projected from different intrinsic states and then a band mixing calculation is performed for each nucleus to obtain bands of positive parity states. For negative parity band, we consider 8, 10, 8 and 7 excited intrinsic states for ^{76,78,80,82}Sr respectively. These excited intrinsic states are obtained by making particle-hole excitations over the lowest HF intrinsic state. Good angular momentum states are projected from each of these intrinsic states and then a band mixing calculation is performed. We do not consider the oblate states since they are not likely to occur at low energy in this region.

3. Results

The calculated levels are classified into different bands on the basis of the $B(E2)$ values between them. The comparison between experimental spectrum and theoretical spectrum for the four nuclei is given in Figures 2–5. For ^{76}Sr, only four levels *viz* : $J = 0^+, 2^+, 4^+$ and 6^+ have been experimentally identified. Our calculation quite nicely reproduces these levels. In addition, we have predicted many collective bands of both positive and negative parity. The lowest $K = 0^+$ bands in ^{78,80}Sr are nicely reproduced. Experimentally, levels with $J = 3^+, 5^+, 7^+, \ldots$ have been observed for ^{80}Sr. These levels agree quite well with the odd J levels of our calculated $K = 2^+$ band. Probably the experimentalists failed to observe the even J levels. The calculated ground band for ^{82}Sr is relatively compressed compared to experiment. The $K = 2^+$ band compares quite well with experiment. Except for the first few levels, the odd-even staggering is correctly reproduced. In addition we have predicted a large number of collective bands for these nuclei. We hope our calculation will stimulate further experiment in these nuclei.

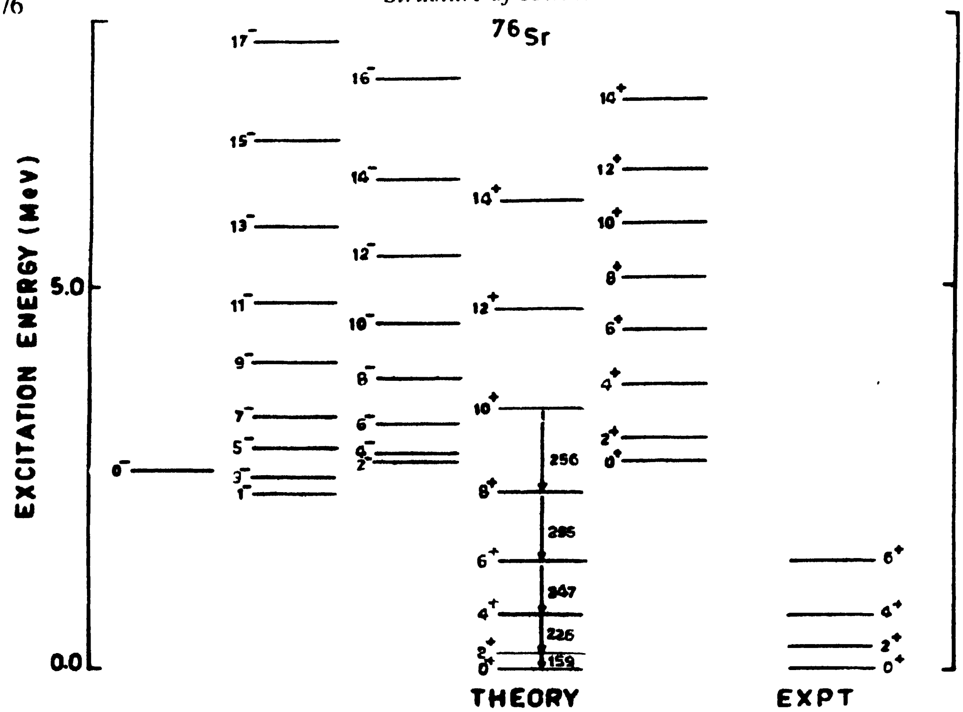

Figure 2. Comparison of the calculated spectrum with experiment in ^{76}Sr

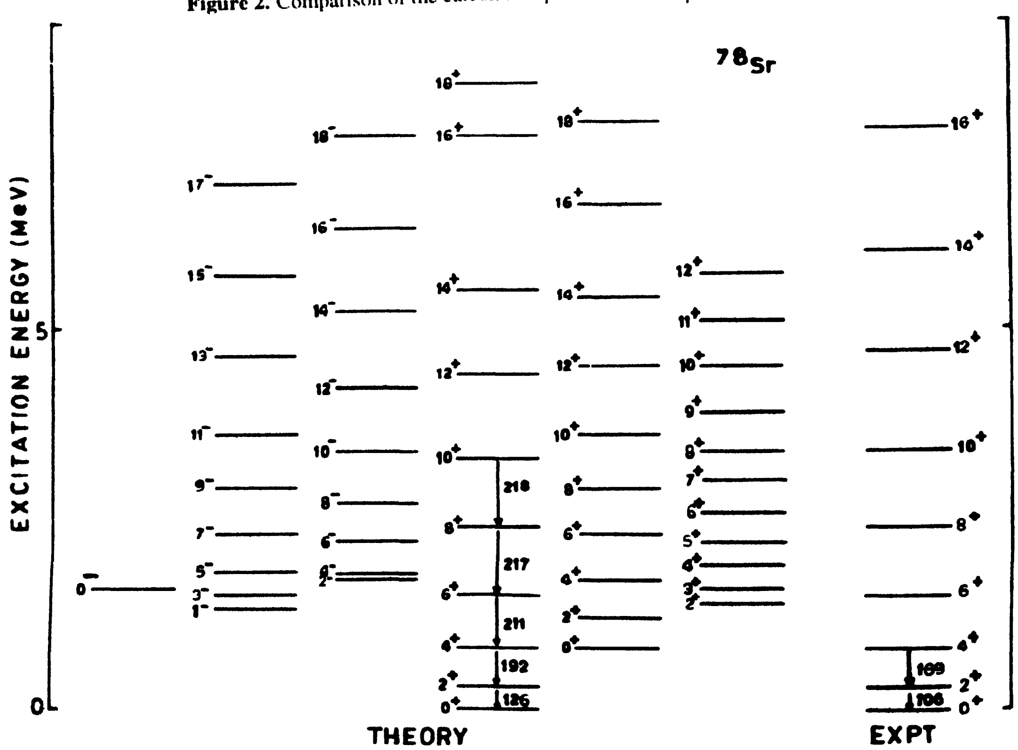

Figure 3. Comparison of the calculated spectrum with experiment in ^{78}Sr.

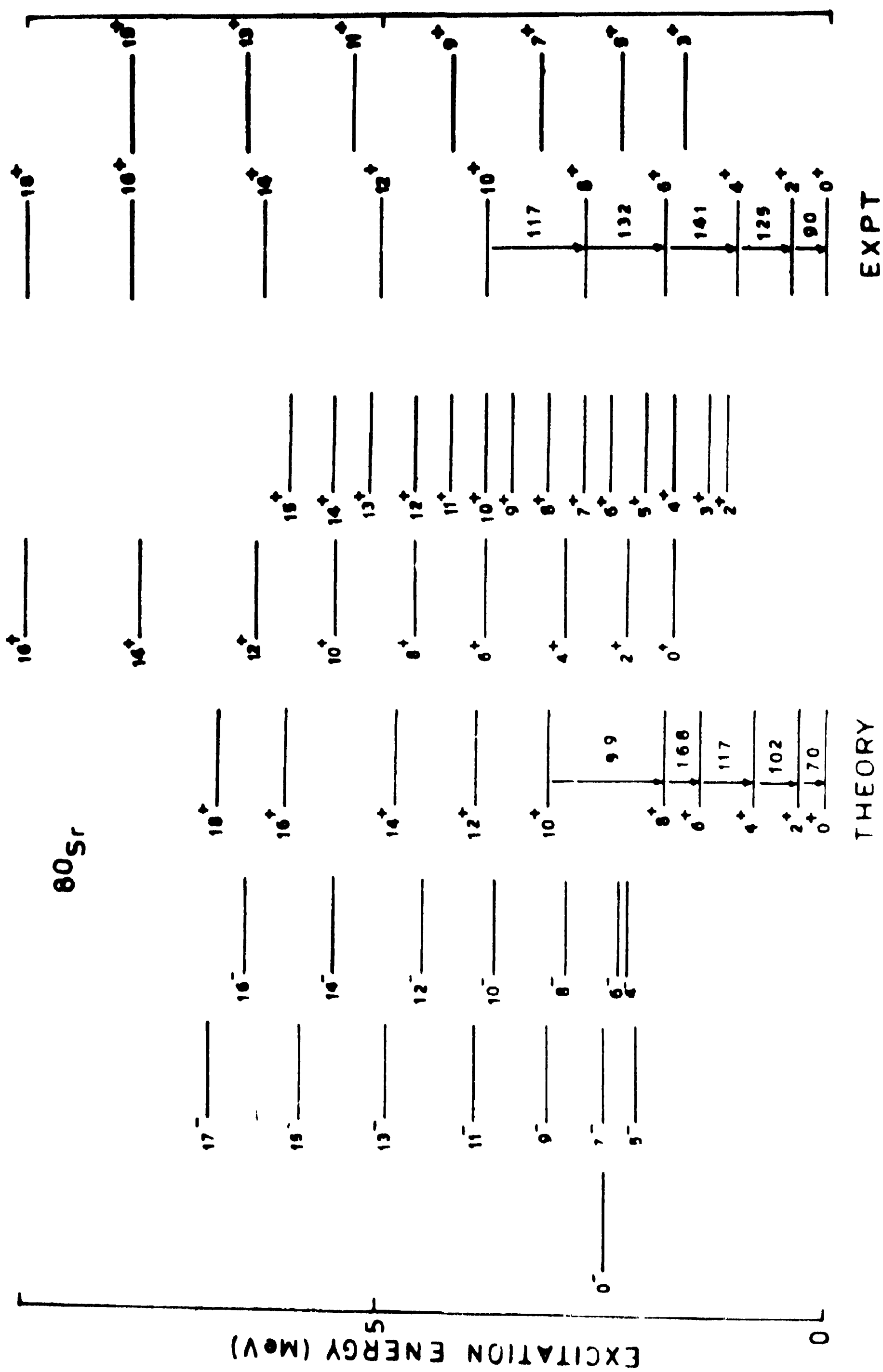

Figure 4. Comparison of the calculated spectrum with experiment in ^{80}Sr

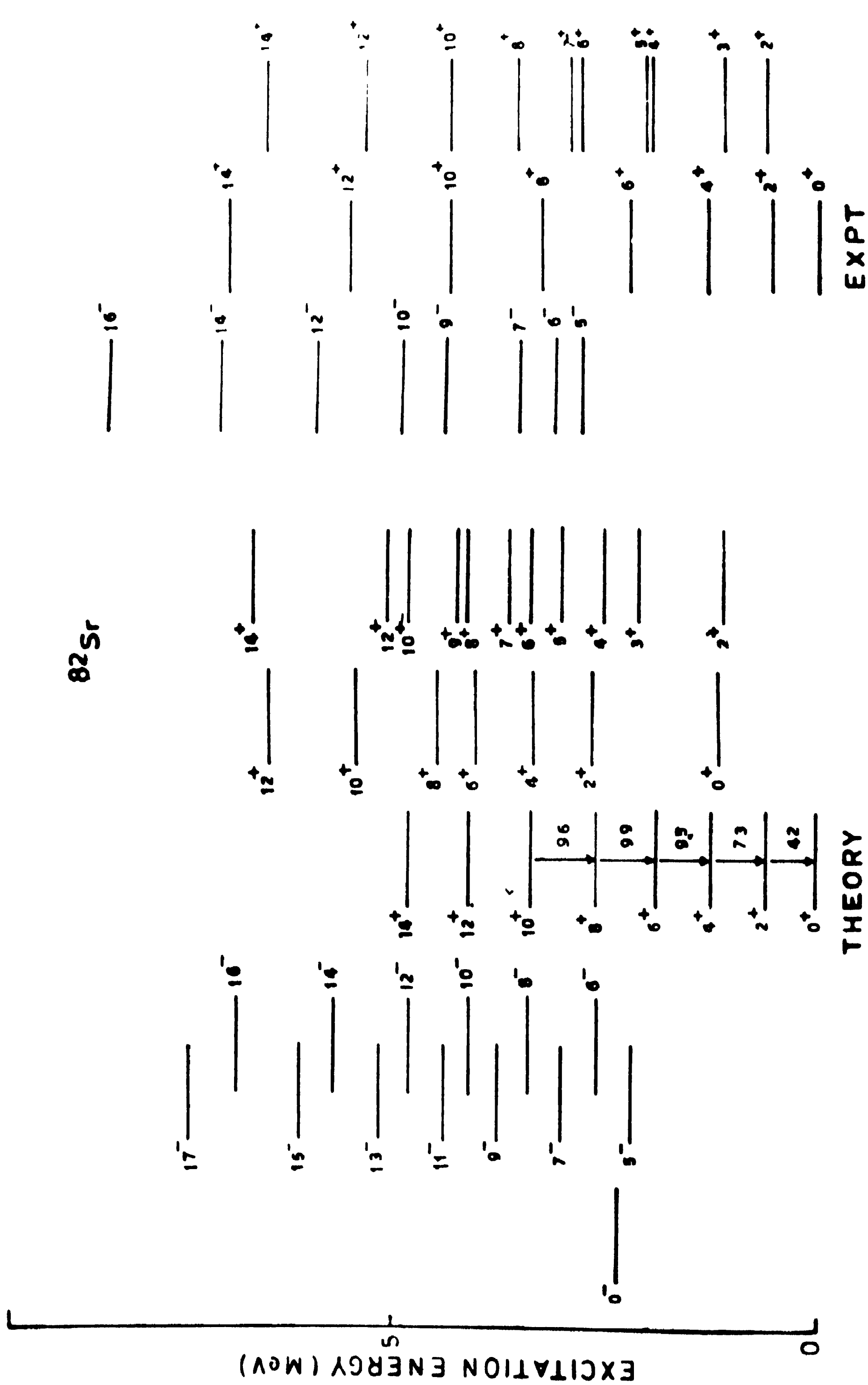

Figure 5. Comparison of the calculated spectrum with experiment in ^{82}Sr.

4. Conclusion

We have tried to understand the structure of collective bands in ^{76,78,80,82}Sr within our microscopic model. The occurrence of large ground state deformation can be quite naturally described within our model. The calculated collective bands agree quite well with experiment.

References

[1] C J Lister *et al Phys. Rev. Lett.* **49** 308 (1982)

[2] R Sahu and S P Pandya *Nucl. Phys* **A529** 20 (1991)

[3] A K Dhar *et al Nucl. Phys.* **A238** 340 (1975)